10 Rec'd PCT/PTO 07 MAR 2002

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 USC 371 AND 37 CFR 1.491 (U S. DEPARTMENT OF COMMERCE, PATENT AND TRADEMARK OFFICE)		ATTORNEY DOCKET NO. 215855 U.S. APPLICATION NO. 10/070469
INTERNATIONAL APPLICATION NO. PCT/GB00/03368	INTERNATIONAL FILING DATE 1 September 2000	PRIORITY DATE CLAIMED 9 September 1999

TITLE OF INVENTION
ADAPTIVE MULTIFILAR ANTENNA

APPLICANT(S) FOR DO/EO/US
SAUNDERS, Simon R., AGIUS, Andreas-Albertos, and LEACH, Stephen

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 USC 371 and 37 CFR 1.491.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 USC 371 and 37 CFR 1.491.
3. ☐ This is an express request to begin national examination procedures (35 USC 371(f)).
4. ☐ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 USC 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 USC 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 USC 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 USC 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 USC 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 USC 371(c)(5)).
11. Nucleotide and/or Amino Acid Sequence Submission
   a. ☐ Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. ☐ CD-ROM or CD-R (2 copies); or
      ii. ☐ Paper Copy
   c. ☐ Statement verifying identity of above copies

Items 12 to 19 below concern other document(s) or information included:

12. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
   ☐ Form PTO-1449
   ☐ Copies of Listed Documents
13. ☐ An assignment for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
14. ☒ A FIRST preliminary amendment.
   ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ Application Data Sheet Under 37 CFR 1.76
18. ☒ Return Receipt Postcard
19. ☐ Other items or information:

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U.S. APPLICATION NO. 10/070469	INTERNATIONAL APPLICATION NO. PCT/GB00/03368	ATTORNEY DOCKET NO 215855

				CALCULATIONS	PTO USE ONLY
20. ☒ The following fees are submitted: **Basic National Fee (37 CFR 1.492(a)(1)-(5)):** Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .... $1,040.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO .... $ 890.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO, but international search fee (37 CFR 1.445(a)(2))paid to USPTO .... $ 740.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4)........................ $ 710.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1) to (4) .... $ 100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT=				$1,040.00	
Surcharge of $130.00 for furnishing the National fee or oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date				$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	25 -20=	5	x $ 18.00	$90.00	
Independent Claims	2 - 3 =	0	x $ 84.00	$0.00	
☐ Multiple Dependent Claim(s) (if applicable)			+$280.00	$0.00	
TOTAL OF ABOVE CALCULATIONS=				$1,130.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				$	
SUBTOTAL=				$1,130.00	
Processing fee of **$130.00** for furnishing English Translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date.				$	
TOTAL NATIONAL FEE=				$1,130.00	
Fee for recording the enclosed assignment. The assignment must be accompanied by an appropriate cover sheet. **$40.00** per property +				$	
TOTAL FEE ENCLOSED=				$1,130.00	
				Amount to be: refunded	$
				charged:	$

a. ☒ A check in the amount of $1,130.00 to cover the above fee is enclosed.

b. ☐ Please charge Deposit Account No. 12-1216 in the amount of $ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 12-1216. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Customer Number: 23460

23460

PATENT TRADEMARK OFFICE

Gordon R. Coons

Gordon R. Coons, Registration No. 20821
One of the Attorneys for Applicant(s)

Date: March 7, 2002

10/070469
JC13 Rec'd PCT/PTO 07 MAR 2002

PATENT
Attorney Docket No. 215855

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

SAUNDERS et al.

Corres. to International Application No. PCT/GB00/03368

Art Unit: Unassigned

Examiner: Unassigned

Filed: Concurrently

For: ADAPTIVE MULTIFILAR ANTENNA

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Prior to the examination of the above-identified patent application, please enter the following amendments and consider the following remarks.

AMENDMENTS

IN THE CLAIMS:

Please replace claims 3-11, 13-22, and 24 with the following:

3. (Amended) An antenna according to claim 1, wherein the control means is operable to control the operation of the matching circuit to adjust the properties of the multifilar antenna to suit better a current signal to be received or transmitted.

4. (Amended) An antenna according to claim 1, including switch means associated with a plurality of the filaments for selectively altering the electrical length and/or interconnections of the filaments and the signal connections to/from the filaments being at a first end of each filament; and

the switch means being operable to selectively interconnect pairs of filaments a second end of those filaments being remote from the first end.

5. (Amended) An antenna according to claim 1, including switchable filaments having switch means for selectively altering the electrical length and/or interconnections of the switchable filaments and

each of the switchable filaments including at least a first filament section and a second filament section; and

the switch means being operable to selectively connect or isolate the first and second filament sections of each switchable filament so as to vary the electrical length of that filament.

6. (Amended) An antenna according to claim 1, in which:

the detecting means is operable to detect a signal to noise ratio of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal to noise ratio of the received signal.

7. (Amended) An antenna according to claim 1, in which:

the detecting means is operable to detect a signal to (noise plus interference) ratio of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal to (noise plus interference) ratio of the received signal.

8. (Amended) An antenna according to claim 1, in which:

the detecting means is operable to detect a signal level of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal level of the received signal.

9. (Amended) An antenna according to claim 1, in which:

the detecting means is operable to detect a VSWR for a transmitted signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the VSWR for transmission of that signal.

10. (Amended) An antenna according to claim 1, in which the detecting means comprises:

analogue to digital conversion means for converting respective signals received by the filaments and/or filament group into corresponding digital representations;

a memory for storing the digital representations;

means for combining the digital representations using respective phase relationships and gains; and

means for detecting properties of the antenna by analysis of the combined digital representations.

11. (Amended) An antenna according to claim 1, in which the detecting means comprises:

means for combining respective signals received by the filaments and/or filament group using respective phase relationships;

analogue to digital conversion means for converting the combined signals into a corresponding digital representation;

a memory for storing the digital representation; and

means for detecting properties of the antenna by analysis of the combined digital representations.

13. (Amended) An antenna according to claim 1, in which the detecting means operates at least during reception of a reference signal burst by the antenna.

14. (Amended) An antenna according to claim 1, in which n is an even integer.

15. (Amended) An antenna according to claim 1, in which n is equal to 4 or 6.

16. (Amended) An antenna according to claim 1, wherein n is 4 and including two filament groups each of two diametrically opposed filaments, the filaments in each respective group being coupled together with a phase weighting of substantially 180°.

17. (Amended) An antenna according to claim 1 wherein the filaments in the or each filament group have a diversity correlation of 0.7 or better.

18. (Amended) An antenna according to claim 1, in which the filaments are helically shaped.

19. (Amended) An antenna according to claim 1, in which the filaments are at least partially intertwined.

20. (Amended) An antenna according to claim 1, having a volute of generally elliptical or rectangular axial cross-section.

21. (Amended) An antenna according to claim 1, wherein the weighting circuit operates at baseband.

22. (Amended) An antenna according to claim 1, wherein the weighting circuit operates at RF.

24. (Amended) An antenna according to claim 1, including a matching circuit for matching the characteristic impedance of the antenna to that of a transmitting and/or receiving apparatus.

Please cancel claim 26:

In re Appln. of Saunders et al.
Corres. to Int'l Application No. PCT/GB00/03368

REMARKS

Claims 1-25 are currently pending in the present application. Claims 3-11, 13-22 and 24 have been amended to remove the multiple dependency of those claims. Claim 26 has been cancelled as it is in not in proper U.S. patent practice format. No new matter has been made by way of these amendments.

If, in the opinion of the Examiner, a telephone conference would expedite the prosecution of the subject application, the Examiner is invited to call the undersigned attorney.

Respectfully submitted,

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Date: March 7, 2002

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PATENT
Attorney Docket No. 215855

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

SAUNDERS et al.

Corres. to International
Application No. PCT/GB00/03368

Filed: Concurrently

For: ADAPTIVE MULTIFILAR ANTENNA

Art Unit: Unassigned

Examiner: Unassigned

**AMENDMENTS TO THE CLAIMS
MADE VIA PRELIMINARY AMENDMENT**

Please amend claims 3-11, 13-22, and 24 as follows:

3. (Amended) An antenna according to claim 1 [or claim 2], wherein the control means is operable to control the operation of the matching circuit to adjust the properties of the multifilar antenna to suit better a current signal to be received or transmitted.

4. (Amended) An antenna according to [any preceding] claim 1, including switch means associated with a plurality of the filaments for selectively altering the electrical length and/or interconnections of the filaments and the signal connections to/from the filaments being at a first end of each filament; and

the switch means being operable to selectively interconnect pairs of filaments a second end of those filaments being remote from the first end.

5. (Amended) An antenna according to [any preceding] claim 1, including switchable filaments having switch means for selectively altering the electrical length and/or interconnections of the switchable filaments and

each of the switchable filaments including at least a first filament section and a second filament section; and

the switch means being operable to selectively connect or isolate the first and second filament sections of each switchable filament so as to vary the electrical length of that filament.

6. (Amended) An antenna according to [any one of the preceding claims] claim 1, in which:

the detecting means is operable to detect a signal to noise ratio of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal to noise ratio of the received signal.

7. (Amended) An antenna according to [any one of the preceding claims] claim 1, in which:

the detecting means is operable to detect a signal to (noise plus interference) ratio of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal to (noise plus interference) ratio of the received signal.

8. (Amended) An antenna according to [any one of the preceding claims] claim 1, in which:

the detecting means is operable to detect a signal level of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal level of the received signal.

9. (Amended) An antenna according to [any one of the preceding claims] claim 1, in which:

the detecting means is operable to detect a VSWR for a transmitted signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the VSWR for transmission of that signal.

10. (Amended) An antenna according to [any one of the preceding claims] claim 1, in which the detecting means comprises:

analogue to digital conversion means for converting respective signals received by the filaments and/or filament group into corresponding digital representations;

a memory for storing the digital representations;

means for combining the digital representations using respective phase relationships and gains; and

means for detecting properties of the antenna by analysis of the combined digital representations.

11. (Amended) An antenna according to [any one of claims] claim 1 [to 9], in which the detecting means comprises:

means for combining respective signals received by the filaments and/or filament group using respective phase relationships;

analogue to digital conversion means for converting the combined signals into a corresponding digital representation;

a memory for storing the digital representation; and

means for detecting properties of the antenna by analysis of the combined digital representations.

13. (Amended) An antenna according to [any one of the preceding claims] claim 1, in which the detecting means operates at least during reception of a reference signal burst by the antenna.

14. (Amended) An antenna according to [any one of the preceding claims] claim 1, in which n is an even integer.

15. (Amended) An antenna according to [any one of the preceding claims] claim 1, in which n is equal to 4 or 6.

16. (Amended) An antenna according to [any preceding] claim 1, wherein n is 4 and including two filament groups each of two diametrically opposed filaments, the filaments in each respective group being coupled together with a phase weighting of substantially 180°.

17. (Amended) An antenna according to [any preceding] claim 1 wherein the filaments in the or each filament group have a diversity correlation of 0.7 or better.

18. (Amended) An antenna according to [any one of the preceding claims] claim 1, in which the filaments are helically shaped.

19. (Amended) An antenna according to [any one of the preceding claims] claim 1, in which the filaments are at least partially intertwined.

20. (Amended) An antenna according to [any preceding] claim 1, having a volute of generally elliptical or rectangular axial cross-section.

21. (Amended) An antenna according to [any preceding] claim 1, wherein the weighting circuit operates at baseband.

22. (Amended) An antenna according to [any of claims] claim 1 [to 18], wherein the weighting circuit operates at RF.

24. (Amended) An antenna according to [any preceding] claim 1, including a matching circuit for matching the characteristic impedance of the antenna to that of a transmitting and/or receiving apparatus.

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PATENT
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

SAUNDERS et al.

Corres. to International
Application No. PCT/GB00/03368

Art Unit: Unassigned

Examiner: Unassigned

Filed: Concurrently

For: ADAPTIVE MULTIFILAR ANTENNA

**PENDING CLAIMS AFTER
ENTRY OF PRELIMINARY AMENDMENT**

1. An adaptive multifilar antenna comprising:

n spaced filaments, where n is an integer greater than 1;

at least one filament group having a predetermined plurality of the filaments coupled together in a fixed phase relationship;

a weighting circuit operable to apply phase adjustments to signals passed to and/or from the n filaments and/or filament group;

detecting means operable to detect at least one electrical property of the multifilar antenna with respect to the frequency, polarisation and/or direction of propagation of a signal to be received or transmitted by the multifilar antenna and/or impedance matching of the antenna; and

control means, responsive to the detecting means, operable to control the operation of the weighting circuit to .adjust the properties of the multifilar antenna to suit better a current signal to be received or transmitted.

2. An antenna according to claim 1, wherein the weighting circuit is operable to apply gain adjustments to signals passed to and/or from the filaments and/or filament group.

3. An antenna according to claim 1, wherein the control means is operable to control the operation of the matching circuit to adjust the properties of the multifilar antenna to suit better a current signal to be received or transmitted.

4. An antenna according to claim 1, including switch means associated with a plurality of the filaments for selectively altering the electrical length and/or interconnections of the filaments and the signal connections to/from the filaments being at a first end of each filament; and

the switch means being operable to selectively interconnect pairs of filaments a second end of those filaments being remote from the first end.

5. An antenna according to claim 1, including switchable filaments having switch means for selectively altering the electrical length and/or interconnections of the switchable filaments and

each of the switchable filaments including at least a first filament section and a second filament section; and

the switch means being operable to selectively connect or isolate the first and second filament sections of each switchable filament so as to vary the electrical length of that filament.

6. An antenna according to claim 1, in which:

the detecting means is operable to detect a signal to noise ratio of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal to noise ratio of the received signal.

7. An antenna according to claim 1, in which:

the detecting means is operable to detect a signal to (noise plus interference) ratio of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal to (noise plus interference) ratio of the received signal.

8. An antenna according to claim 1, in which:

the detecting means is operable to detect a signal level of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal level of the received signal.

9. An antenna according to claim 1, in which:

the detecting means is operable to detect a VSWR for a transmitted signal;

and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the VSWR for transmission of that signal.

10. An antenna according to claim 1, in which the detecting means comprises:

analogue to digital conversion means for converting respective signals received by the filaments and/or filament group into corresponding digital representations;

a memory for storing the digital representations;

means for combining the digital representations using respective phase relationships and gains; and

means for detecting properties of the antenna by analysis of the combined digital representations.

11. An antenna according to claim 1, in which the detecting means comprises:

means for combining respective signals received by the filaments and/or filament group using respective phase relationships;

analogue to digital conversion means for converting the combined signals into a corresponding digital representation;

a memory for storing the digital representation; and

means for detecting properties of the antenna by analysis of the combined digital representations.

12. An antenna according to claim 11, wherein the combining means is operable to combine the respective signals using respective gain weighting.

13. An antenna according to claim 1, in which the detecting means operates at least during reception of a reference signal burst by the antenna.

14. An antenna according to claim 1, in which n is an even integer.

15. An antenna according to claim 1, in which n is equal to 4 or 6.

16. An antenna according to claim 1, wherein n is 4 and including two filament groups each of two diametrically opposed filaments, the filaments in each respective group being coupled together with a phase weighting of substantially 180°.

17. An antenna according to claim 1 wherein the filaments in the or each filament group have a diversity correlation of 0.7 or better.

18. An antenna according to claim 1, in which the filaments are helically shaped.

19. An antenna according to claim 1, in which the filaments are at least partially intertwined.

20. An antenna according to claim 1, having a volute of generally elliptical or rectangular axial cross-section.

21. An antenna according to claim 1, wherein the weighting circuit operates at baseband.

22. An antenna according to claim 1, wherein the weighting circuit operates at RF.

23. An antenna according to claim 20, wherein the respective outputs of the weighting circuit are combined prior to frequency downconversion.

24. An antenna according to claim 1, including a matching circuit for matching the characteristic impedance of the antenna to that of a transmitting and/or receiving apparatus.

25. An adaptive multifilar antenna comprising:

n spaced antenna filaments, where n is an integer greater than 1;

at least one filament group having a predetermined plurality of the filaments coupled together in a fixed phase relationship;

a matching circuit for matching the characteristic impedance of the antenna to that of a transmitting and/or receiving apparatus;

a phasing circuit for applying respective gain and phase adjustments to signals passed to and/or from the n filaments and/or filament group;

switch means associated with each filament for selectively altering the electrical length and/or interconnections of the filaments;

means for detecting electrical properties of the multifilar antenna with respect to the frequency, polarisation and/or direction of propagation of a signal to be received or transmitted by the multifilar antenna and/or impedance matching of the antenna; and

control means, responsive to the detecting means, for controlling the operation of the matching circuit, the phasing circuit and the switch means to adjust the properties of the multifilar antenna to suit better a current signal to be received or transmitted.

ADAPTIVE MULTIFILAR ANTENNA

This invention relates to adaptive multifilar antennas.

In fields such as mobile telephony and communication, it is being proposed that radio frequency transceivers operating in different frequency bands, and providing different services, should be integrated into single consumer devices.

For example, in order to improve the coverage area in which a mobile telephone can be used, a satellite system transceiver, a terrestrial transceiver and a domestic cordless telephone transceiver might be integrated into one hand-held unit. An alternative example is a dual service telephone operating at 1800MHz in the user's home country but having the capability of operating at 900MHz in other countries under a so-called roaming arrangement.

The electronics needed to achieve this aim are rapidly becoming smaller and lighter. A remaining problem area for multi-frequency, multi-system operation, however, is the antenna.

In order to operate as described above, an antenna should be able to work at different frequencies and with different types of base station. For example, one service may

use terrestrial base stations and another may use orbiting satellites. This means that if the handset antenna is typically used in a vertical position (with the handset held next to the user's head) then for one service the antenna should have a radiation pattern substantially omnidirectional. in azimuth and for the other service it should have an approximately hemispherical radiation pattern.

To cater for the different pattern and frequencies in use, it has been proposed to employ at least two distinct antennas within a common volute.

In a first aspect, the invention provides an adaptive multifilar antenna comprising:

n spaced filaments, where n is an integer greater than 1;

at least one filament group having a predetermined plurality of the filaments coupled together in a fixed phase relationship;

a weighting circuit operable to apply phase adjustments to signals passed to and/or from the n filaments and/or filament group;

detecting means operable to detect at least one electrical property of the multifilar antenna with respect to the frequency, polarisation and/or direction of propagation of

a signal to be received or transmitted by the multifilar antenna and/or impedance matching of the antenna; and

control means, responsive to the detecting means, operable to control the operation of the weighting circuit to adjust the properties of the multifilar antenna to suit better a current signal to be received or transmitted.

In another aspect, this invention also provides an adaptive multifilar antenna comprising:

n spaced antenna filaments, where n is an integer greater than 1;

at least one filament group having a predetermined plurality of the filaments coupled together in a fixed phase relationship;

a matching circuit for matching the characteristic impedance of the antenna to that of a transmitting and/or receiving apparatus;

a phasing circuit for applying respective gain and phase adjustments to signals passed to and/or from the n filaments and/or filament group;

switch means associated with each filament for selectively altering the electrical length and/or interconnections of the filaments;

means for detecting electrical properties of the multifilar antenna with respect to the frequency, polarisation and/or direction of propagation of a signal to be received or transmitted by the multifilar antenna and/or impedance matching of the antenna; and

control means, responsive to the detecting means, for controlling the operation of the matching circuit, the phasing circuit and the switch means to adjust the properties of the multifilar antenna to suit better a current signal to be received or transmitted.

In the invention, the phase and/or gain relationships for signals from individual filaments of a multifilar antenna, and optionally also with the electrical length and/or interconnection pattern of the filaments, can be varied automatically in order to improve (or possibly to optimise, within the resolution of the adjustment system) the properties of the antenna for a particular signal to be received or transmitted. The automatic variation may be applied identically to predetermined groups of individual filaments.

For example, in embodiments of the invention, at least one of the above parameters could be varied to provide the best received signal level, the best signal to noise ratio,

or the best signal to (noise plus interference) ratio and/or the best VSWR.

The adjustments will generally lead to a change in the antenna's frequency response and radiation pattern (shape and polarisation). It may not matter to the adjustment system what that change is quantitatively; the system may simply measure the output and make adjustments so as to improve the handling of the current signal.

The invention will now be described by way of example with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:

Figure 1 is a schematic diagram of a quadrifilar helical antenna (QHA);

Figure 2 is a schematic diagram of an antenna interface circuit;

Figure 3 is a more detailed schematic diagram of one possible implementation of the antenna system of Figure 2;

Figure 4 is a more detailed schematic diagram of another possible implementation of the antenna system of Figure 2;

Figure 5 is an enlarged view of an alternative for the portion of Figure 3 enclosed in dotted lines;

Figure 6 is an enlarged view of an alternative for the portion of Figure 4 enclosed in dotted lines; and

Figure 7 is a plot comparing the diversity performance of differently configured QHAs.

With reference to Figure 1, a QHA comprises four helical elements 10..40 and eight radial elements 50..120. (In other embodiments six, for example, angularly spaced helical elements could be used). It will also be noted that not all the radial elements 50..120 will be present in all antenna configurations.

The helical elements are intertwined as shown in Figure 1, and are disposed about a longitudinal axis of the antenna by 90° with respect to one another. Four of the radials 50..80 are disposed on the top and four 90..120 on the bottom of the volute, connecting the helical elements and forming two bifilar loops. The antenna is fed on one set of radials 90,110 with 90° phase difference between the two feeds.

The radials 50..80 at the top end of the antenna with respect to the feeds (which in this

example are at the bottom) may be shorted in pairs or may be open-circuit depending on the resonant length of the helical elements and the required response.

The QHA is described in the following references:

[1] Kilgus C.C., "Multielement, Fractional Turn Helices", IEEE Transactions on Antenna and Propagation, Vol.AP-16, pp.499-500, July 1968

[2] Kilgus C.C., "Resonant Quadrifilar Helix", IEEE Transactions on Antenna and Propagation, Vol.AP-17, pp. 349-351, May 1969

[3] Kilgus C.C., "Resonant Quadrifilar Helix Design", The Microwave Journal, December 1970.

The antenna's radiation pattern mode (hemispherical or other) depends on the phase combination used on the two or four feeds. The exact shape of the antenna's radiation pattern in each mode depends on the pitch and dimensions of the helices. In the axial mode it has a shape varying from hemispherical to cardioid depending on the dimensions of the structure. The polarisation is circular with a very good axial ratio inside the 3dB angle.

In other embodiments, the multifilar antenna arrangement can also be used for diversity purposes. The different filaments can be used to provide space diversity between generally uncorrelated received signals. The effect of weighting the gain and/or phase can affect both the shape and the polarisation of the radiation pattern. This effect can benefit the transceiver in two ways. Firstly, the pattern shape and the polarisation are matching the direction and the polarisation of the incoming signal to try to optimise or improve the criterion ratio (S/N or S/(N+I), and secondly the structure can be used for polarisation diversity using the resulting pattern of different filaments or pairs of filaments.

Figure 1 shows an antenna which has a generally cylindrical volute (i.e. circular in plan). Other volute shapes such as those having elliptical or rectangular plans or a truncated cone shape are also suitable for use in the present invention.

Figure 2 is a schematic diagram of an antenna system comprising an adapted QHA 200 and an antenna interface circuit.

In Figure 2, the four elements of the QHA 200 are connected separately to an adaptive matching circuit 210. (In the configuration shown in Figure 2, the antenna is in a receive mode, but it will be clear that signals could instead be supplied to the antenna, in a transmit mode, by reversing the direction of signal propagation arrows in Figure

2.) The adaptive matching circuit 210 is under the control of a matching controller 220, which in turn is respective to a system controller 230.

Received signals from the adaptive matching circuit are supplied to four respective variable weighting circuits W1..W4. Each of W1..W4 comprises a variable phase delay and optionally, a variable gain stage, all controllable by the system controller 230.

An alternative which is described in more detail below is to combine diametrically opposite pairs of elements (10,30 and 20,40) with fixed 180° weights at RF so that the antenna has only two feeds (each relating to a respective diametric pair) and therefore requires only two weighting circuits W1,W2 and two transceivers 400 and 450.

In the embodiment of Figure 2, the outputs of the four variable weighting elements W1..W4 are combined by an adder/weight combiner 240 to form a composite signal. This composite signal is then stored in a store 250. A sensor 280 examines the signal (e.g. the level of the signal to (noise plus interference) ratio) and passes this information to the controller which in turn adjusts the weighting factors of the weighting elements W1..W4, the matching circuit 210 and the switch elements 290,300 to improve or possibly optimise the parameter sensed by the sensor 280. The optimisation information can be used to optimise or improve the quality of the stored

signal, which is then passed to the demodulator 260. The information is also used to adjust the antenna system to receive the next incoming signal.

In each element of the QHA, there is a switch 290 capable of isolating a portion of the element remote from the feed point. The switch could be, for example, a PIN diode switch. Similarly, a switch 300 is capable of shorting or isolating pairs of the elements at the end remote from the feed point.

The operations performed by the switches 290 and 300, under the control of a switch controller 310, can change the response and radiation pattern of the antenna. In particular, by isolating a section of each element, the electrical length of the elements is made shorter and so the frequency of operation will be higher. Again, these operations are carried out under the control of the system controller to improve or possibly optimise operation with a particular signal frequency, polarisation and direction of propagation.

Alternatively, or additionally, the antenna element may be caused to have several resonant modes by the inclusion of one or more antenna traps. This causes the antenna to be resonant (and therefore have increased gain) at more than one operating frequency.

Figure 3 is a more detailed schematic diagram of one possible implementation of the antenna system of Figure 2, which also shows operation to improve or optimise the VSWR during a transmission operation and S/N+I during a receive mode. (Incidentally, when S/N+I is improved by adapting the antenna matching in a receive mode, this has an indirect side-effect of tending to improve the VSWR. Also, when the pattern mode, polarisation and direction are improved by adjusting for the best or an improved S/N+I, this similarly has a corresponding improving effect in a transmit mode.)

In Figure 3, the operation of the weighting elements W1..W4 is carried out at baseband in a digital domain, as is the operation of the adder/weight combiner 240.

The output of the adaptive matching circuit 210 is supplied to a quadrature downconverter 400 comprising an intermediate stage 410 where a local oscillator signal is mixed with the radio frequency signal, an amplifier 420 and a further stage of mixing with a local oscillator signal with a 0° and 90° phase relationship to generate two demodulated outputs I and Q. These are both converted to digital representations by A/D converters 430 before being stored in a RAM 440. This process is replicated for each of the elements of the QHA. Similarly, for the transmit side, an output from the RAM 440 is passed to a quadrature modulator 450 before being routed via the adaptive matching circuit 210 to the respective antenna elements.

A VSWR detector 460 operates in a transmit and/or receive mode to detect the standing wave ratio of the antennas. The output of this is stored in the RAM 440.

The RAM is connected to a digital signal processing (DSP) unit 470 which combines the digital representations of the signals stored in the RAM 440 in respective proportions and using respective phases (i.e. performs the operation of the weighting blocks W1..W4), detects and optimises the selected parameter such as signal-to-noise ratio, sends control signals to the adaptive matching circuits to change from one frequency band to another or to overcome de-tuning effects, and also controls the switch controller 310 and in turn the switches 290,300 within the helical elements.

One appropriate DSP algorithm is for the transmitter to send packet header, reference or training symbols, which are known to the receiver. Any disturbance to the received signals during the reception of the training symbols is a measure of N+I and can be reduced by trial and error (repeated combining of the digital representations stored in the RAM 440), direct matrix inversion of the associated correlation matrix or by iteration approaches such as so-called LMS or RLS algorithms. However, even if known training symbols are not available, a measure of the disturbance to the signal can be made by error detection algorithms applied to the received symbols.

Figure 4 is a more detailed schematic diagram of an alternative implementation of the

antenna system of Figure 2. This implementation has a quadrature downconverter 400' which operates in the same way as the downconverter 400 of Figure 3. Similarly, it has a quadrature modulator 450' which operates in the same way as the modulator 450 of Figure 3.

The operation at baseband of the implementation shown in Figure 4 is also similar to that of Figure 3 in that the downconverted signals are converted into the digital domain and stored in a RAM 440'. The data in the RAM is processed by a digital signal processing unit 470' and the DSP 470' is operable to cause changes in the adaptive matching circuit 210' and in the antenna switches 290',300' and 310'.

However, the operation of a circuit of Figure 4 differs significantly from that of Figure 3 in that the weighting operation is performed at RF in weighting blocks 500 which are coupled in the signal path from the individual antenna elements to the quadrature downconverter 400'.

In Figure 4, the weighting block 500 is coupled directly between the adaptive matching circuit 210' and a combiner 240' which operates to additively combine the outputs of the respective weighting circuits W1,W2,W3,W4 contained in the weighting block 500.

The output of the combiner 240' is fed into a single quadrature downconverter 400'. Thus, unlike the implementation shown in Figure 3, only one downconverter 400' is required. Similarly, only one quadrature modulator 450' is required.

This alternative implementation has two main advantages. Firstly, since only one downconverter 400' and one modulator 450' is required, there is a resultant cost saving in the manufacture of the transceiver.

Secondly, since most of the noise in the received signal is introduced by the receiver, there is a fourfold decrease in the noise added by the receiver section since the signal passes through only one (instead of four) downconverters 400'. As a further subsidiary advantage, since the signal from all four antenna elements is subjected to the same noise in the single downconverter 400', it is not necessary to apply gain weightings. Thus the weighting circuits W1,W2,W3,W4 may be arranged only to apply phase adjustments to the signals received by the antenna elements. This simplifies their construction and therefore also has cost and reliability advantages.

In order to optimise the weightings, a slightly different approach may be taken to that used with the implementation of Figure 3. It will be noted that in the implementation of Figure 3, the stored data may be iteratively processed with different weighting applied to the data until an optimal or at least improved result is obtained. However,

in the implementation of Figure 4, the data stored in the RAM 440' already has weighting applied to it and in fact the signals from each of the elements of the antenna have already been combined by the combiner 240'. Thus, in order to find the correct weighting, the weighting are adjusted dynamically during reception of a signal (for example a training sequence). By storing data representing the known weighting settings against data representing the quality of the received signal, it is possible to determine which weighting gives the best reception and/or transmission characteristics. Thus the principles are similar but in the first case (Figure 3) the weighting optimisation may occur "off line" whereas in the implementation of Figure 4, the weighting optimisation occurs "on line" during reception of a signal.

As mentioned above, the number of weighting blocks (and in the case of the embodiment shown in Figure 3, of up and down converters) may be reduced by coupling together predetermined antenna elements. This has the advantage of reducing further the complexity of the circuit and therefore its cost.

In the preferred embodiment using a quadrifilar helical antenna as shown in Figure 1, the predetermined groups of antennas are two groups containing the diametrically opposite pairs of elements 10,30 and 20,40 respectively.

The Table below shows the diversity correlation coefficient matrix for each of the

elements. The figures have been derived from complex coefficients produced empirically. It will be noted that in the table below, the diametrically opposite pairs of elements have correlation coefficients in excess of 0.7.

Table 1 : Diversity parameters for four elements of the QHA

Correlation coefficient matrix	Element 10	Element 20	Element 30	Element 40
Element 10	1.00	0.13	0.75	0.14
Element 20	0.13	1.00	0.17	0.76
Element 30	0.75	0.17	1.00	0.20
Element 40	0.14	0.76	0.20	1.00

Thus, although the grouping of elements is described below in connection with two pairs of elements, on a more general level, the predetermined groups of elements may be groups of elements which are each correlated to within 0.6, preferably 0.7 and more preferably 0.8 or better.

For the quadrifilar helical antenna described below, the pairs of elements are coupled in pairs with a 180° phase shift. This may be achieved using fixed combiners or baluns B1, B2 as shown in Figures 5 and 6.

Looking particularly at Figure 5, it will be noted that the components shown in that Figure can be used to replace the components shown within the dotted outline on

Figure 3. This allows the circuit in Figure 3 to only have two up and down converters 400, 450 which reduces cost. Although Figure 5 does not show an adaptive matching circuit 210, this could be included.

Figure 6 shows the equivalent modification for the circuit of Figure 4. Similarly, the adaptation of Figure 6 could include an adaptive matching circuit 210'.

The circuits of Figures 5 and 6 could also include provision for structure switches 290, 300 or 290', 300' respectively.

The grouping of elements in this way may produce a slightly reduced diversity gain compared to the earlier described circuit in which all four elements are independently adjusted.

However, Figure 7 shows a comparison of the performance of a QHA having four independently adjusted elements and a QHA in which the elements are combined into two pairs, against a standard QHA (which has been normalised to the 0dB level). It will be seen that the diversity gain penalty for using the grouped configuration is only about 1dB in areas of deep shadow with high multipath and that there is an advantage in situations where the signal is not significantly decorrelated between elements (for example, in environments where there is a direct line of sight between the base station

transceiver and the antenna).

Thus it will be seen that the optimal solution will usually be separate control of each element 10..40. However, a very satisfactory compromise may be reached between cost and performance by carefully selecting elements (for example according to their diversity correlation coefficient, however measured) and combining these elements with suitable fixed phase shifts to provide a reduced number of antenna feeds.

CLAIMS

1. An adaptive multifilar antenna comprising:

n spaced filaments, where n is an integer greater than 1;

at least one filament group having a predetermined plurality of the filaments coupled together in a fixed phase relationship;

a weighting circuit operable to apply phase adjustments to signals passed to and/or from the n filaments and/or filament group;

detecting means operable to detect at least one electrical property of the multifilar antenna with respect to the frequency, polarisation and/or direction of propagation of a signal to be received or transmitted by the multifilar antenna and/or impedance matching of the antenna; and

control means, responsive to the detecting means, operable to control the operation of the weighting circuit to adjust the properties of the multifilar antenna to suit better a current signal to be received or transmitted.

2. An antenna according to claim 1, wherein the weighting circuit is operable to

apply gain adjustments to signals passed to and/or from the filaments and/or filament group.

3. An antenna according to claim 1 or claim 2, wherein the control means is operable to control the operation of the matching circuit to adjust the properties of the multifilar antenna to suit better a current signal to be received or transmitted.

4. An antenna according to any preceding claim, including switch means associated with a plurality of the filaments for selectively altering the electrical length and/or interconnections of the filaments and the signal connections to/from the filaments being at a first end of each filament; and

the switch means being operable to selectively interconnect pairs of filaments a second end of those filaments being remote from the first end.

5. An antenna according to any preceding claim, including switchable filaments having switch means for selectively altering the electrical length and/or interconnections of the switchable filaments and

each of the switchable filaments including at least a first filament section and a second filament section; and

the switch means being operable to selectively connect or isolate the first and second filament sections of each switchable filament so as to vary the electrical length of that filament.

6. An antenna according to any one of the preceding claims, in which:

the detecting means is operable to detect a signal to noise ratio of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal to noise ratio of the received signal.

7. An antenna according to any one of the preceding claims, in which:

the detecting means is operable to detect a signal to (noise plus interference) ratio of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal to (noise plus interference) ratio of the received signal.

8. An antenna according to any one of the preceding claims, in which:

the detecting means is operable to detect a signal level of a received signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the signal level of the received signal.

9. An antenna according to any one of the preceding claims, in which:

the detecting means is operable to detect a VSWR for a transmitted signal; and

the control means is operable to control the operation of the matching circuit and/or the weighting circuit so as to improve the VSWR for transmission of that signal.

10. An antenna according to any one of the preceding claims, in which the detecting means comprises:

analogue to digital conversion means for converting respective signals received by the filaments and/or filament group into corresponding digital representations

a memory for storing the digital representations;

means for combining the digital representations using respective phase relationships and gains; and

means for detecting properties of the antenna by analysis of the combined digital representations.

11. An antenna according to any one of claims 1 to 9, in which the detecting means comprises:

means for combining respective signals received by the filaments and/or filament group using respective phase relationships

analogue to digital conversion means for converting the combined signals into a corresponding digital representation;

a memory for storing the digital representation; and

means for detecting properties of the antenna by analysis of the combined digital representations.

12. An antenna according to claim 11, wherein the combining means is operable

to combine the respective signals using respective gain weighting.

13. An antenna according to any one of the preceding claims, in which the detecting means operates at least during reception of a reference signal burst by the antenna.

14. An antenna according to any one of the preceding claims, in which n is an even integer.

15. An antenna according to any one of the preceding claims, in which n is equal to 4 or 6.

16. An antenna according to any preceding claim, wherein n is 4 and including two filament groups each of two diametrically opposed filaments, the filaments in each respective group being coupled together with a phase weighting of substantially 180°.

17. An antenna according to any preceding claim wherein the filaments in the or each filament group have a diversity correlation of 0.7 or better.

18. An antenna according to any one of the preceding claims, in which the filaments are helically shaped.

19. An antenna according to any one of the preceding claims, in which the filaments are at least partially intertwined.

20. An antenna according to any preceding claim, having a volute of generally elliptical or rectangular axial cross-section.

21. An antenna according to any preceding claim, wherein the weighting circuit operates at baseband.

22. An antenna according to any of claims 1 to 18, wherein the weighting circuit operates at RF.

23. An antenna according to claim 20, wherein the respective outputs of the weighting circuit are combined prior to frequency downconversion.

24. An antenna according to any preceding claim, including a matching circuit for matching the characteristic impedance of the antenna to that of a transmitting and/or receiving apparatus.

25. An adaptive multifilar antenna comprising:

n spaced antenna filaments, where n is an integer greater than 1;

at least one filament group having a predetermined plurality of the filaments coupled together in a fixed phase relationship;

a matching circuit for matching the characteristic impedance of the antenna to that of a transmitting and/or receiving apparatus;

a phasing circuit for applying respective gain and phase adjustments to signals passed to and/or from the n filaments and/or filament group;

switch means associated with each filament for selectively altering the electrical length and/or interconnections of the filaments;

means for detecting electrical properties of the multifilar antenna with respect to the frequency, polarisation and/or direction of propagation of a signal to be received or transmitted by the multifilar antenna and/or impedance matching of the antenna; and

control means, responsive to the detecting means, for controlling the operation of the matching circuit, the phasing circuit and the switch means to adjust the properties of the multifilar antenna to suit better a current signal to be received or transmitted.

26. A multifilar antenna substantially as hereinbefore described with reference to the accompanying drawings.

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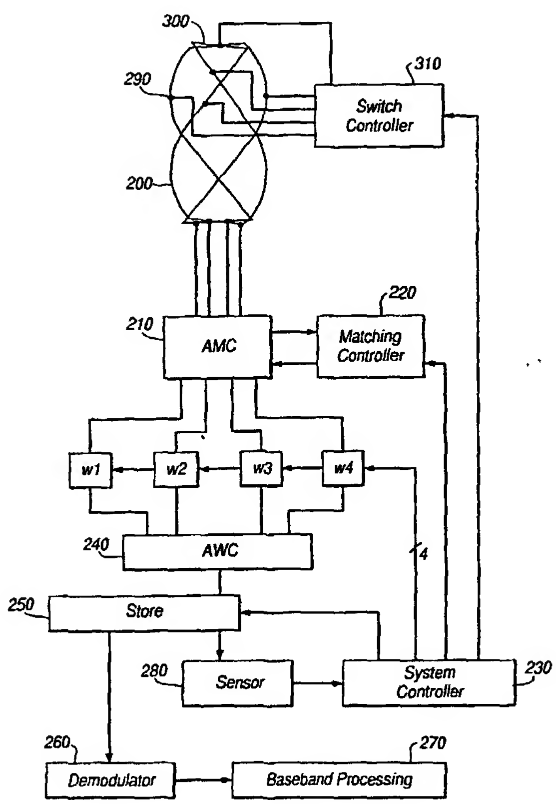
(54) Title: ADAPTIVE MULTIFILAR ANTENNA



(57) Abstract: A multifilar antenna (200) comprises n spaced antenna filaments, where n is an integer greater then 1; a matching circuit (210) for matching the characteristic impedance of the antenna to that of a transmitting and/or receiving apparatus; a weighting circuit (240) for applying gain and phase adjustments to signals passed to or from the n filaments; switch means (310) associated with at least some of the filaments for selectively altering the electrical length and/or interconnections of the filaments; means for detecting electrical properties of the multifilar antenna with respect to the frequency, polarisation and/or direction of propagation of a signal to be received or transmitted by the multifilar antenna and/or impedance matching of the antenna; and control means (230), responsive to the detecting means, for controlling the operation of the matching circuit (210), the weighting circuit (240) and the switch means (310) to adjust the properties of the multifilar antenna (200) to suit better a current signal to be received or transmitted.

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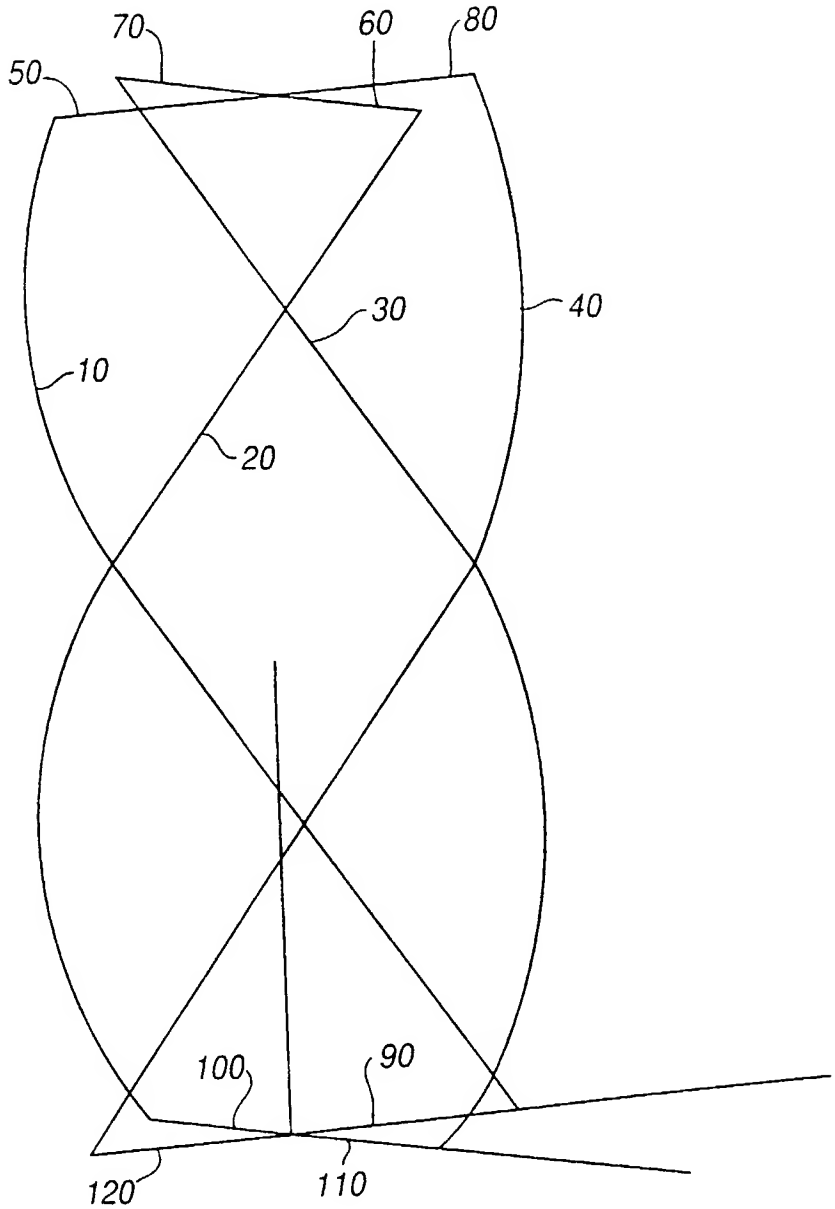

Fig.1

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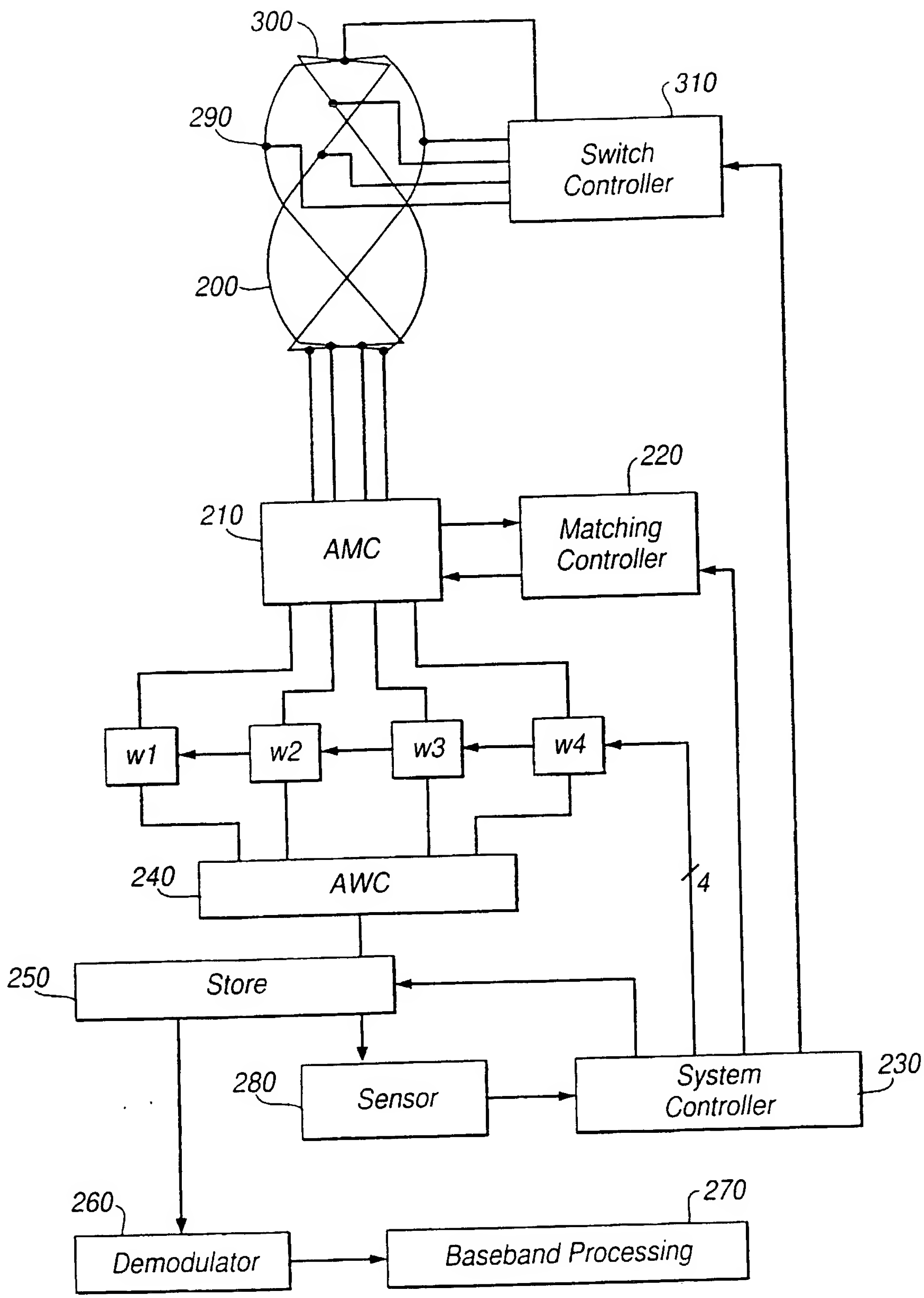
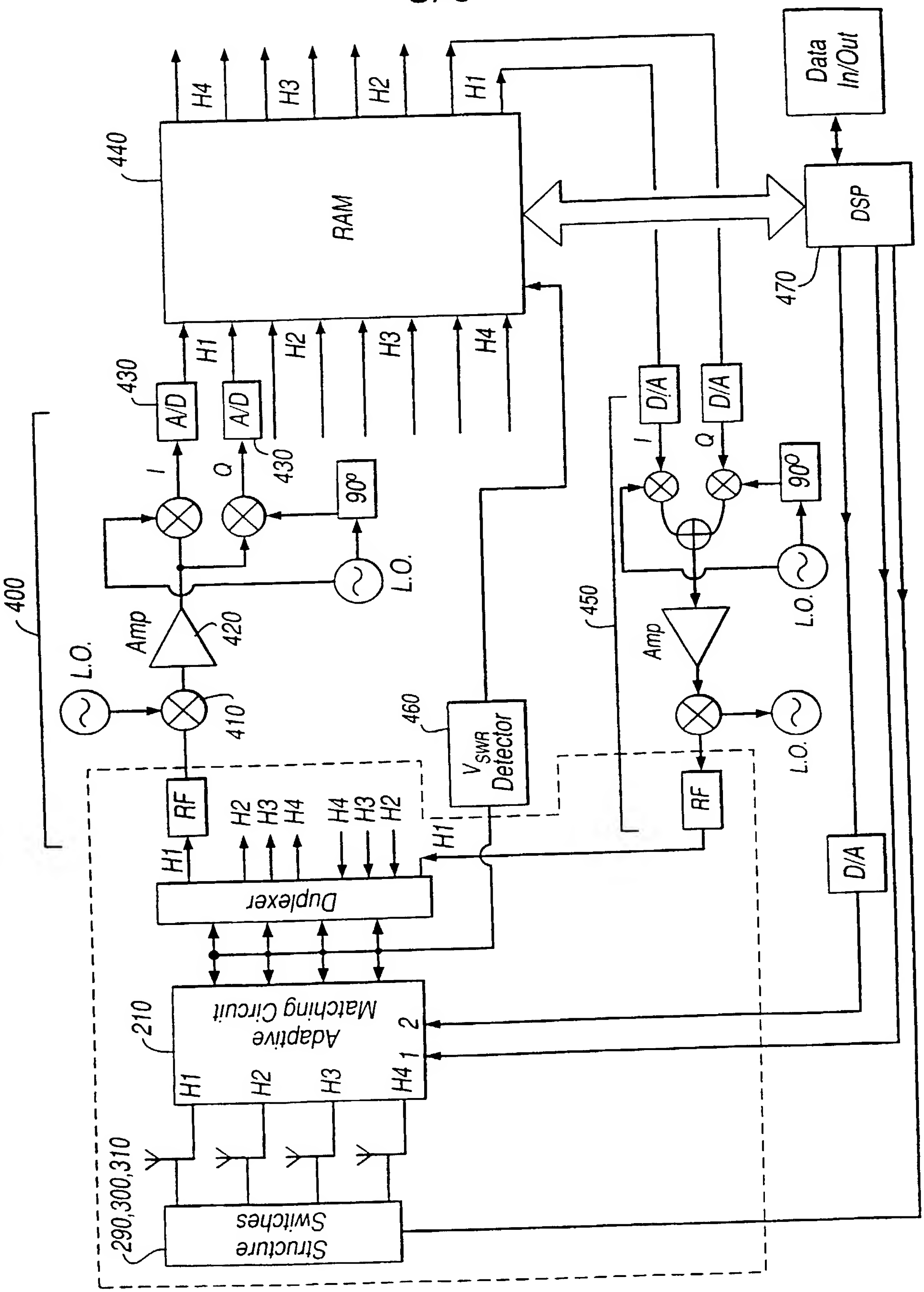

300
290
310
Switch Controller
200
220
210
AMC
Matching Controller
w1
w2
w3
w4
4
240
AWC
250
Store
280
Sensor
System Controller
230
260
270
Demodulator
Baseband Processing

Fig.2



400
L.O.
410
Amp
420
L.O.
I
Q
90°
A/D
430
430
H1
H2
H3
H4
RAM
440
H1
H2
H3
H4
Data
In/Out
DSP
470
D/A
D/A
I
Q
90°
L.O.
Amp
450
L.O.
RF
460
V_{SWR}
Detector
RF
H1
H2
H3
H4
H4
H3
H2
H1
Duplexer
Adaptive
Matching Circuit
210
H1
H2
H3
H4
1
2
D/A
290,300,310
Structure
Switches

Fig.3

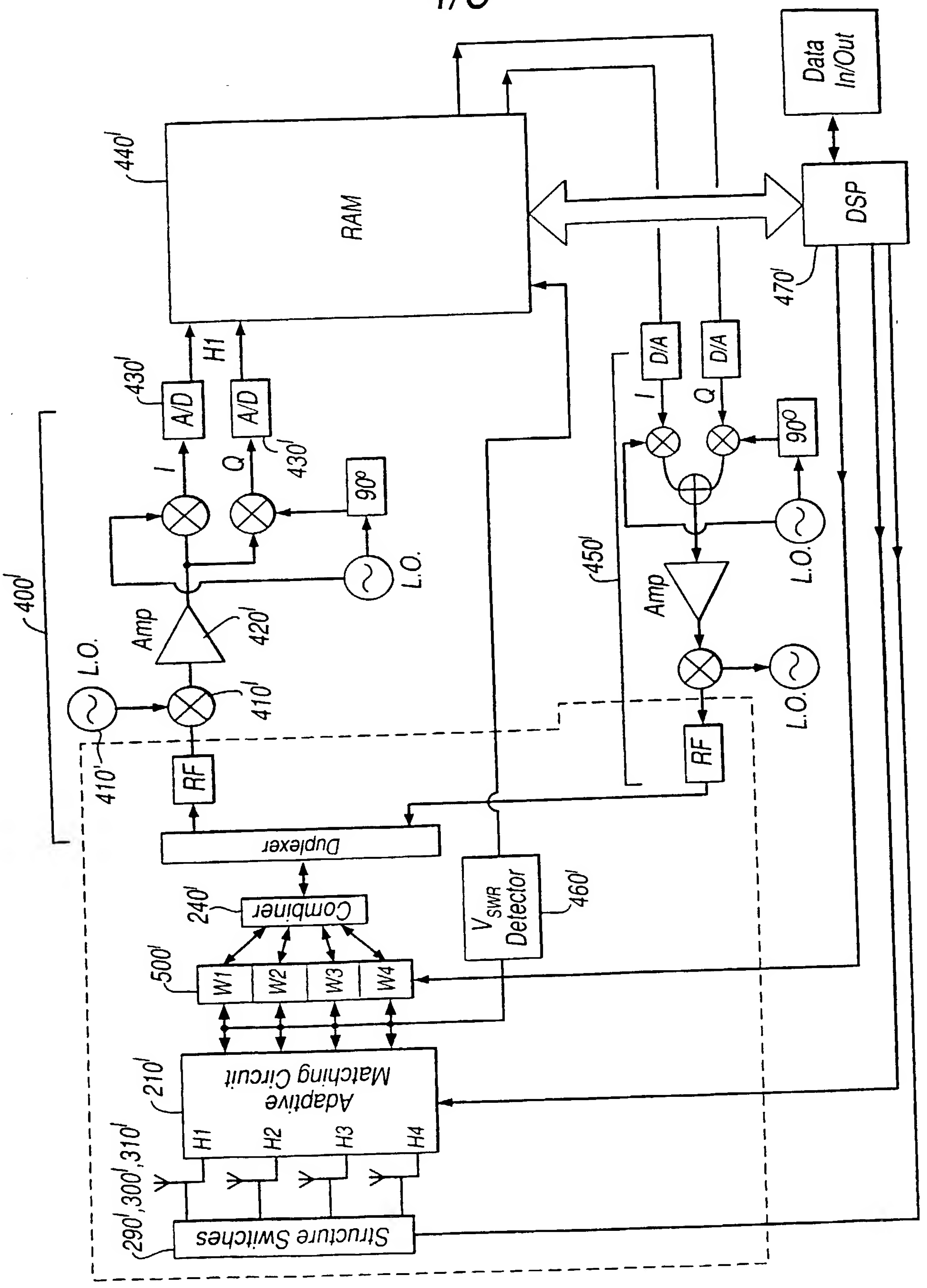

RAM
440'
Data In/Out
DSP
470'
A/D
430'
H1
I
Q
90°
L.O.
400'
Amp
420'
410'
RF
D/A
450'
Duplexer
Combiner
240'
500'
W1
W2
W3
W4
V_{SWR} Detector
460'
Adaptive Matching Circuit
210'
H1
H2
H3
H4
290',300',310'
Structure Switches

Fig.4

5/6

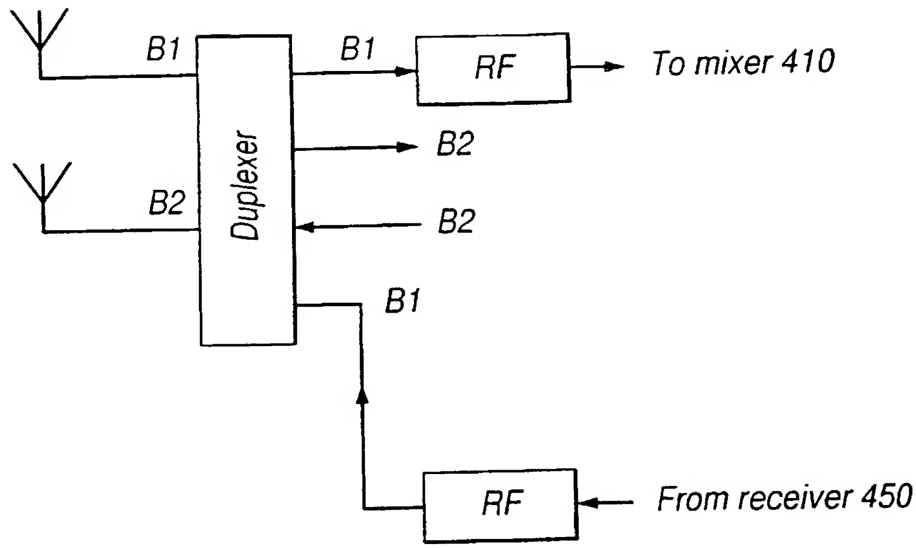

B1
B1
RF
To mixer 410
Duplexer
B2
B2
B2
B1
RF
From receiver 450

Fig.5

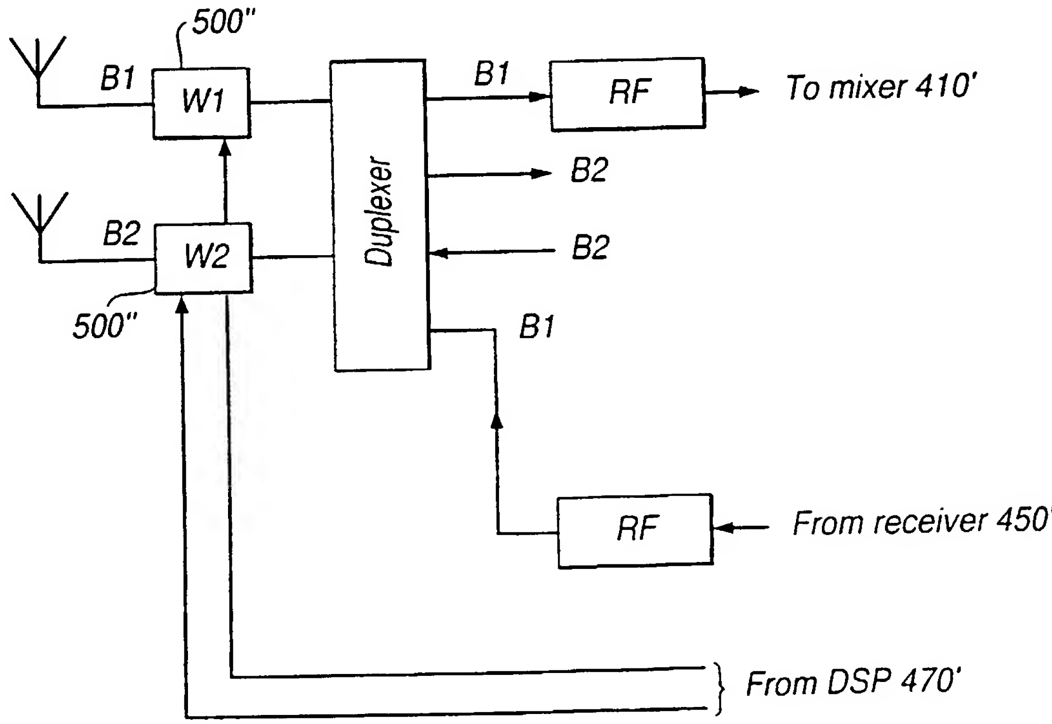

500"
B1
W1
B1
RF
To mixer 410'
Duplexer
B2
B2
W2
B2
500"
B1
RF
From receiver 450'
From DSP 470'

Fig.6

6/6

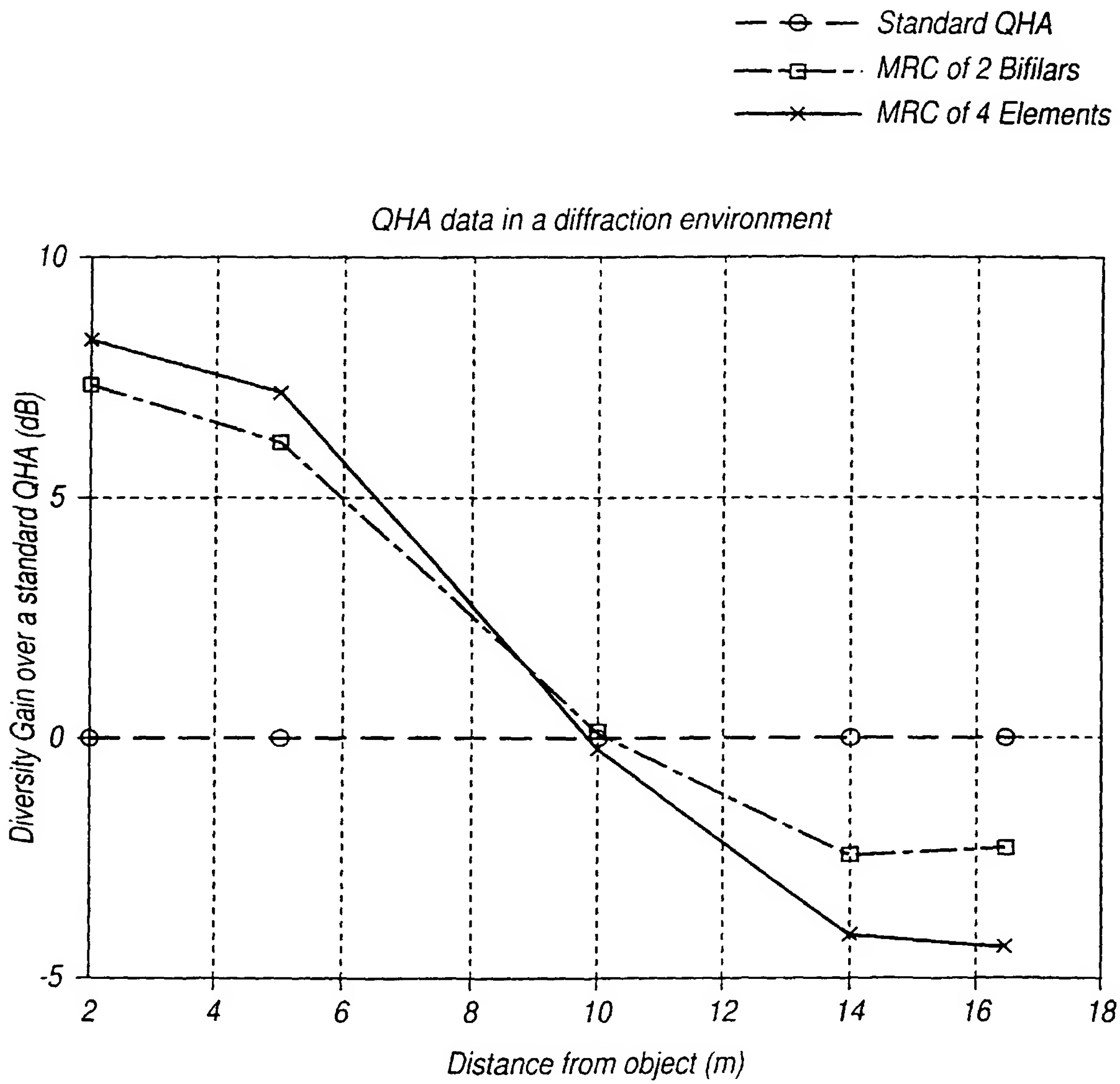

Standard QHA
MRC of 2 Bifilars
MRC of 4 Elements
QHA data in a diffraction environment
Diversity Gain over a standard QHA (dB)
10
5
0
-5
2
4
6
8
10
12
14
16
18
Distance from object (m)

Fig.7

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PATENT
Attorney's Docket No. 215855

COMBINED DECLARATION AND POWER OF ATTORNEY

As below named inventor, I hereby declare that

This declaration is of the following type:
☐ original ☐ design ☐ supplemental
☒ national stage of PCT
☐ divisional ☐ continuation ☐ continuation-in-part

My residence, post office address, and citizenship are as stated below next to my name. I believe I am the original, first, and sole inventor *(if only one name is listed below)* or an original, first, and joint inventor *(if plural names are listed below)* of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Adaptive Multifilar Antenna

the specification of which:

☐ is attached hereto.
☐ was filed on as Application No. and was amended on ____________________ *(if applicable)*.
☐ was filed by Express Mail No. *as Application No. not known yet*, and was amended on ____________________ *(if applicable)*.
☒ was described and claimed in PCT International Application No. GB00/03368 filed on 1 Sept 2000 and as amended pursuant to PCT Article 19 on ____________________ *(if any)*.

I state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above.

I acknowledge the duty to disclose information that is material to the patentability of this application in accordance with 37 C.F.R. § 1.56.

I claim foreign priority benefits under 35 U.S.C. § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent, utility model, design registration, or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

PRIOR FOREIGN PATENT, UTILITY MODEL, AND DESIGN REGISTRATION APPLICATIONS						
COUNTRY	APPLICATION	DATE OF FILING (day,**month**,year)	PRIORITY CLAIMED UNDER 35 U.S.C. § 119			
UNITED KINGDOM	9921363.9	9 Sept 1999	X	YES		NO
				YES		NO
				YES		NO

I claim the benefit pursuant to 35 U.S.C. § 119(e) of the following United States provisional application(s):

In re Appln. of
Attorney Docket No.

PRIOR U.S. PROVISIONAL APPLICATIONS BENEFIT CLAIMED UNDER 35 U.S.C. 119(e)	
APPLICATION NO.	DATE OF FILING (day,**month**,year)

I claim the benefit pursuant to 35 U.S.C. § 120 of any United States application(s) or PCT international application(s) designating the United States of America listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. § 1.56 effective between the filing date of the prior application(s) and the national or PCT international filing date of this application.

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL PATENT APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120					
U.S. APPLICATIONS			Status *(check one)*		
APPLICATION NO.	U.S. FILING DATE		PATENTED	PENDING	ABANDONED
1. 0 /					
2. 0 /					
3. 0 /					
PCT APPLICATIONS DESIGNATING THE U.S.			Status *(check one)*		
PCT APPLICATION NO.	PCT FILING DATE (day,**month**,year)	U.S. APPLN. NOS. ASSIGNED (if any)	PATENTED	PENDING	ABANDONED
4. GB00/03368	1 Sept 2000				
5.					
6.					

DETAILS OF FOREIGN APPLICATIONS FROM WHICH PRIORITY CLAIMED UNDER 35 U.S.C. §119 FOR ABOVE LISTED U.S./PCT APPLICATIONS				
ABOVE APPLN. NO.	COUNTRY	APPLICATION NO.	DATE OF FILING (day,**month**,year)	DATE OF ISSUE (day,**month**,year)
1. GB00/03368	UNITED KINGDOM	9921363.9	9 Sept 1999	
2.				
3.				
4.				
5.				
6.				

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In re Appln. of
Attorney Docket No.

As a named inventor, I hereby appoint Leydig, Voit & Mayer, Ltd. to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: Customer Number 23460.

23460

PATENT TRADEMARK OFFICE

I further direct that correspondence concerning this application be directed to Leydig, Voit & Mayer, Ltd.: Customer Number 23460.

23460

PATENT TRADEMARK OFFICE

I declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1[00]

Full name of **sole or first inventor**: Simon Reza Saunders

Inventor's signature X Simon Reza Saunders

Date X 25TH FEBRUARY 2002

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2[00]

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